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ABSTRACT

This strategic plan, based on two years of coordinated interagency effort, presents a five-year planning framework and associated milestones that focus the plans and resources of the participating Federal agencies toward achieving the National Education Goals in terms of the competence in mathematics and science expected of all students. The Plan also identifies three tiers of program activities, presented in descending order of priority, with goals that address issues in science, mathematics, engineering, and technology education meriting special attention. Within each tier, individual agency programs play important and often unique roles that strengthen the aggregate portfolio. The following three tiers are discussed: Tier I: Reforming the Formal Education System; Tier II: Expanding Participation Access; and Tier III: Enabling Activities. Implementation of the Plan will require more effective use of extant Federal human and institutional capabilities. Monitoring the progress and performance of activities outlined in the Plan will continue. (PR)

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Pathways to Excellence

A Federal Strategy for Science, Mathematics, Engineering, and Technology Education

FCCSET CEHR
FY 1994-FY 1998

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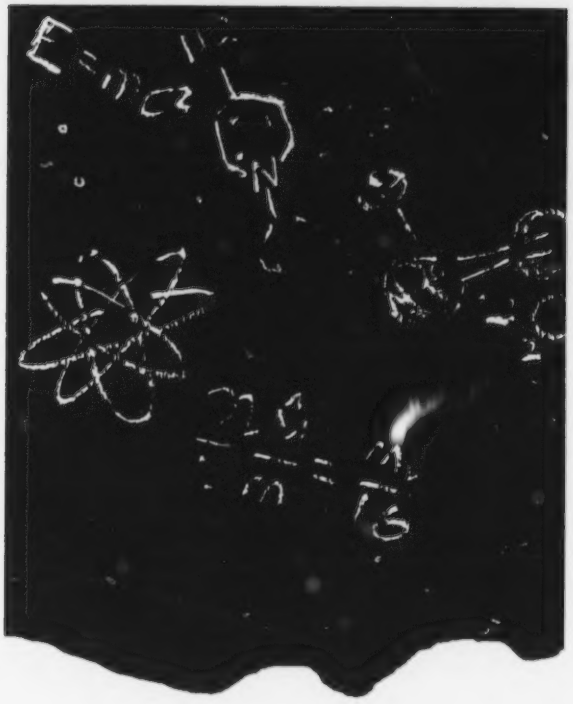
Pathways to Excellence

A Federal Strategy for Science, Mathematics, Engineering, and Technology Education



Federal Coordinating Council
for Science, Engineering,
and Technology

Committee on Education
and Human Resources

On the cover:
A teacher shows
a visiting third-grade
elementary class
the relationship
between the Earth,
Moon, and Sun.

U.S. Science, Mathematics,
Engineering, and Technology
Education Strategic Plan
FY 1994 - FY 1998

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

January 6, 1993

I am pleased to release *Pathways to Excellence: A Federal Strategy for Science, Mathematics, Engineering, and Technology Education*, a report prepared by the Committee on Education and Human Resources (CEHR) of the Federal Coordinating Council for Science, Engineering and Technology (FCCSET).

The National Education Goals, adopted by the President and the Nation's Governors in 1990, and America 2000, have served to guide the planning and programmatic activities of the CEHR agencies. This Strategic Plan, based on two years of coordinated interagency effort, presents a five-year planning framework and associated milestones that focus the plans and resources of the participating Federal agencies toward achieving the Goals in terms of the competence in mathematics and science expected of all U.S. students.

For the first time we have a unitary Federal strategy and program for mathematics and science education. The FCCSET CEHR program for improving mathematics and science education is a Presidential initiative. The CEHR agencies have aligned their programs to be mutually supportive of the common goals, while maintaining the integrity of each agency's mission responsibilities.

I want to salute the leadership that Admiral James D. Watkins, CEHR Chairman and Secretary of Energy, brought to this task. He was ably assisted by the Co-Vice Chairmen, David T. Kearns, Deputy Secretary of Education, and Luther S. Williams, Assistant Director for Education and Human Resources at the National Science Foundation. The level of coordination represented by this Strategic Plan was derived from the commitment of the heads of the participating CEHR departments and agencies to achieving the National Education Goals.

This Plan is being widely distributed to encourage discussion and comment by the Congress, State and local government leaders, teachers, parents, industrial leaders, educational and community leaders, the media and others interested in the Federal role in achieving the National Education Goals.

I believe that the accomplishments of the FCCSET in this area truly reflect the value of this mechanism, namely to provide sustained interagency efforts to achieve goals broader than the missions of the individual participating agencies.

D. Allan Bromley
Director

The Secretary of Energy
WASHINGTON, D.C. 20585

January 5, 1993

Dr. D. Allan Bromley
Assistant to the President
for Science and Technology
The White House
Washington, D.C. 20506

Dear Allan:

It is my pleasure to transmit to you, *Pathways to Excellence: A Federal Strategy for Science, Mathematics, Engineering, and Technology Education*, which provides a programmatic framework for the implementation of the Executive Order on Improving Mathematics and Science Education, signed by the President on November 16, 1992.

This Plan is the result of nearly three years of coordinated effort by the 16 Federal agencies holding membership in the FCCSET Committee on Education and Human Resources. This report stands as an important landmark in their concerted effort because it lays out clearly identified, measurable milestones and objectives in seven program categories, deliverable between 1994 and 1998. This five-year plan will be continuously updated and revised each year to maintain progress toward meeting the National Education Goals, especially Goals #3, #4, and #5, which specifically address mathematics and science education, by the year 2000.

The CEHR Strategic Plan also provides a framework to link education reform with efforts such as the National Technology Initiative which seek to stimulate technology growth and innovation in the private sector. Without success on both fronts, this Nation cannot retain its competitive edge and will not be able to produce the quantity of high quality jobs needed to sustain the economic well being of our people.

Special thanks are due to David Kearns, CEHR Co-Vice Chairman and Chairman of the Strategic Plan Working Group; Angela Phillips, Coordinating Secretary for the project; Milt Goldberg, Director of the Strategic Plan Working Group; Tom Corwin, Chairman of the Budget Working Group; and Luther Williams, CEHR Co-Vice Chairman. The scores of employees across all agencies who participated in this historic project deserve our recognition and thanks.

Sincerely,

James D. Watkins
Admiral, U.S. Navy (Retired)
Chairman, FCCSET CEHR

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Third grade students at Dranesville Elementary helping one another on a computer that combines text and graphics

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Executive Order—Improving Mathematics and Science Education in Support of the National Education Goals

Executive Summary

Our country has a fundamental stake in the educational achievement of its citizens. A well-educated citizenry is essential to the civic and economic health and well-being of the country. The Federal Government, therefore, has an important role to play in ensuring that every American child receives an excellent education.

Recent international assessments provide evidence that many of our students are not keeping pace in mathematics and science. As a Nation, we must take action to reverse this trend. America's performance in mathematics and science in the classroom and the workplace must be second to none.

Through the adoption of the National Education Goals (see Figure A on page 4) in 1990 and the launching of *AMERICA 2000* (see Figure B on page 8) in 1991, the President and the Nation's Governors have acted as catalysts and coordinators for educational reform.

Mathematics and science education receives special emphasis in this reform agenda because of its centrality in the education process and because science and technology have a profound effect on our Nation's economic competitiveness and on the quality of life of its citizens.

This Strategic Plan was developed by the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) through its Committee on Education and Human Resources (CEHR), with representatives from 16 Federal agencies. Based on two years of coordinated interagency effort, the Plan confirms the Federal Government's commitment to ensuring the health and well-being of science, mathematics, engineering, and technology education at all levels and in all sectors (i.e., elementary and secondary, undergraduate, graduate, public understanding of science, and technology education).

The Plan represents the Federal Government's efforts to develop a five-year planning framework (see Chart 1 on page 12) and associated milestones that focus Federal planning and the resources of the participating agencies toward achieving the requisite or expected level of mathematics and science competence by all students. The priority framework (see Chart 2 on page 16) outlines the strategic objectives, implementation priorities, and components for the Strategic Plan and serves as a road map for the Plan.

◂ *At Thomas Jefferson's Photo Lab, a teacher discusses a student's print development.*

The Plan endorses a broad range of ongoing activities, including continued Federal support for graduate education as the backbone of our country's research and development enterprise. The Plan also identifies three tiers of program activities, presented in descending order of priority, with goals that address issues in science, mathematics, engineering, and technology education meriting special attention. Within each tier, individual agency programs play important and often unique roles that strengthen the aggregate portfolio.

Tier I: Reforming the Formal Education System

This tier includes systemic reform at the elementary and secondary education level; revitalization of undergraduate education, especially at the lower-division level; and the evaluation of all Federal agency science, mathematics, engineering, and technology education programs. Efforts to redefine what students are expected to learn must begin at the earliest grades.

Tier II: Expanding Participation and Access

This tier includes promoting the participation of individuals from groups underrepresented in science, mathematics, engineering, and technology. If we do not expand their participation, the United States will continue to underutilize this rich pool of talent needed to remain competitive. Also included in this tier are identifying and encouraging the use of all exemplary science, mathematics, engineering, and technology education products and broadening the use of effective educational technologies.

Tier III: Enabling Activities

This tier includes improving public understanding of science and developing partnerships between two-year colleges and other education sectors.

Implementation of the CEHR Strategic Plan will require more effective use of extant Federal human and institutional capabilities as well as, in some cases, additional budgetary resources. It may also require changes in existing laws and regulations to apply effectively the Nation's resources to the achievement of these important reforms.

CEHR will continue to monitor the progress and performance of activities outlined in this Plan, coordinate the efforts of the participating agencies, and recommend necessary revision of efforts.

◂ *Middle school students match rock samples to descriptions of their characteristic at the Ecological and Physical Sciences Study Center at the Oak Ridge National Laboratory in Tennessee.*

The President and the Governors' National Education Goals

By the Year 2000:

1) All the children in America will start school ready to learn.

2) The high school graduation rate will increase to at least 90 percent.

***3)** *American students will leave grades four, eight, and twelve having demonstrated competency in challenging subject matter including English, mathematics, science, history, and geography; and every school in America will ensure that all students learn to use their minds well, so they may be prepared for responsible citizenship, further learning, and productive employment in our modern economy.*

***4)** *U.S. students will be first in the world in science and mathematics achievement.*

***5.** *Every adult American will be literate and will possess the knowledge and skills necessary to compete in a global economy and exercise the rights and responsibilities of citizenship.*

6) Every school in America will be free of drugs and violence and will offer a disciplined environment conducive to learning.

** Goals which specifically address achievement, competency, and literacy in science and mathematics education.*

Introduction

Science and technology are essential to our Nation's economic well-being and the quality of life for our citizens today and in the next century. Our citizens must be equipped to make informed decisions in this age of rapidly developing knowledge, changing technology, and sophisticated information and communications systems. Accordingly, America's performance in science, mathematics, engineering, and technology must be second to none in the classroom and the workplace.

Recent international studies and assessments, however, provide evidence that our students are not keeping pace with those in other countries, particularly in the areas of mathematics and science. If we are to meet our Nation's education goals and maintain our economic position in the world, we must take explicit and concerted action. For this reason, the President and the Nation's Governors established the National Education Goals in 1990 and in 1991 the President implemented *AMERICA 2000*, the national education strategy.

True education reform can be accomplished only when all groups with a vested interest in education are involved. In this context, the Federal Government can provide leadership in education by: forging needed collaboration to stimulate partnerships; leveraging resources from other sectors; developing model programs and exemplary materials; and using its own vast scientific resources to ensure that every child in America receives the best possible education.

Role of the Committee on Education and Human Resources (CEHR)

The Committee on Education and Human Resources (CEHR) was established in 1990 and chartered under the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). CEHR is charged with developing a Federal strategy for science, mathematics, engineering, and technology education that will ensure U.S. world leadership in science and technology, build a highly trained work force, and increase public understanding of science.

CEHR, through its 16 member agencies, provides leadership in science, mathematics, engineering, and technology education by:

- Identifying priorities for Federal initiatives designed to improve and maintain world-class science, mathematics, engineering, and technology education at all levels, from kindergarten through adulthood.

- Encouraging Federal interagency cooperation and collaboration.

- Developing a programmatic and budgetary plan that builds upon the unique educational strengths of each agency, while eliminating unnecessary or ineffective duplication of effort.

• Forging strong linkages between Federal agencies and individual States, colleges, universities, schools, school systems, and the private sector to promote excellence in science, mathematics, engineering, and technology education.

• Identifying and developing model education programs and disseminating successful models to the education community.

• Making the unparalleled scientific resources of the Federal Government, including laboratories, scientists, equipment and materials, available to educators and students.

CEHR Education Strategy

CEHR developed this Strategic Plan to guide the overall Federal effort in science, mathematics, engineering, and technology education while building on its coordinative work over the past two years. This document represents a paradigm shift—moving from an aggregation of multiple agency programs to an integrated, coordinated, and focused multiyear approach for managing and directing the Federal effort in science, mathematics, engineering and technology education. It provides a framework for making policy, programmatic, and budgetary decisions and for assessing the impact of those decisions.

CEHR developed this consensus document through an interagency deliberative process that addressed specific education levels and issues, examined Federal program activities, and identified priorities and milestones.

◀ *Department of Defense Dependents Schools (DODDS) student receives a high quality science education.*

The results of this process are summarized in the following charts:

• Federal Science, Mathematics, Engineering, and Technology Education *Strategic Planning Framework.* (see Chart 1 on page 12)

• FY 1994 Federal Science, Mathematics, Engineering, and Technology Education *Priority Framework.* (see Chart 2 on page 16)

These charts delineate the strategic objectives and implementation priorities for each of the science, mathematics, engineering, and technology education categories.

The CEHR strategy addresses the entire education continuum — i.e., elementary and secondary, undergraduate, graduate education, public understanding of science, and technology education — and supports the National Education Goals and *AMERICA 2000.* Each of the five components identifies different priorities to bring about needed changes in the education system.

This Plan is predicated on the need to maintain the integrity and strength of programs in each area. All are interdependent, and each plays a critical role in meeting the relevant National Education Goals, as well as ensuring America's future economic

America 2000

- ***Strategy to meet the national goals***

- ***Four Tracks***

1) *For today's students*, we must radically improve today's schools by making all 110,000 of them better and more accountable for results.

2) *For tomorrow's students*, we must invent new schools to meet the demands of a new century with a New Generation of American Schools, bringing at least 535 of them into existence by 1996 and thousands by decade's end.

3) *For those of us already out of school and in the work force*, we must keep learning if we are to live and work successfully in today's world. A "Nation at Risk" must become a "Nation of Students."

4) *For schools to succeed*, we must look beyond our classrooms to our communities and families. Schools will never be much better than the commitment of their communities. Each of our communities must become a place where learning can happen.

and technological competitiveness by making today's education relevant to tomorrow's workplace. Moreover, throughout all levels and activities, the Strategic Plan emphasizes increasing the participation of groups presently underrepresented in mathematics and science.

After examining education programs at all levels, CEHR recommends: (1) placing special emphasis on revitalizing elementary and secondary education and (2) seeking fundamental change in mathematics and science education so that *all* American children participate in a rich, challenging curriculum taught by well-qualified teachers. The Plan stresses programs that will achieve significant short-term progress while recognizing that long-term structural changes must also be made to ensure that hard-won gains are not lost and that programs respond effectively to changing needs. To promote such structural change, Federal resources should be linked to incentives and consequences for all participants in science, mathematics, engineering, and technology education.

Further, CEHR emphasizes the importance of developing and implementing ambitious national standards; conducting regular assessments of progress toward meeting those standards; and implementing teacher enhancement programs that lead to a cadre of teachers well-equipped to deliver a restructured curriculum. Systemic reform at the elementary and secondary education levels should assist States and localities in raising expectations so that *all* children study mathematics and science continuously from kindergarten through high school.

Priorities and Milestones

The Strategic Plan focuses on high priority program areas essential for achieving the National Education Goals in science, mathematics, engineering, and technology education. It recognizes the immediate need to put in place a strong and better coordinated Federal program if significant advances are to be made by the end of the decade.

The priorities and milestones address areas of responsibility from kindergarten through postgraduate education, public understanding of science, and technology education. The Plan not only establishes budget planning priorities by identifying those activities that require expansion; it also allows for a more effective and efficient use of resources through redirection of activities, forward-looking interagency planning, and an improved management strategy. The Plan takes advantage of unique agency roles by making greater and more effective educational use of each agency's unique research capabilities and resources.

The Plan's priorities and milestones are grouped into three tiers listed in descending order of priority; within each tier, however, no priority is implied among activities. Not all agencies contribute programs to the first or even second tier; however, these programs are no less important and are in fact essential to the strength and success of the overall CEHR program portfolio.

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Strategic Framework

Base Program

The milestones and priorities presented in the Strategic Plan build on a strong and effective base of current Federal science and mathematics education activities. We must, for example, maintain Federal support for U.S. graduate education, uniformly regarded as the best in the world. Within the elementary and secondary, undergraduate, public understanding of science, and technology education categories, the base program encompasses a variety of activities not specifically identified in the milestones but nonetheless essential for achieving the CEHR objectives. These activities include programs for generic systemic reform, student incentives and opportunities, research-related teacher enhancement, educational technologies, development of courses and instructional materials, science education programs in informal settings, and media-disseminated programming.

Also within the base program are programs that support efforts to promote opportunities for historically underrepresented groups (women, minorities, and persons with disabilities). The objective of expanding the participation of these groups occurs through programs with specialized emphases within all programs under the CEHR purview. Unless we expand the participation of these groups, the United States will continue to underutilize its rich talent pool, a resource the United States needs to remain competitive.

Fifth graders at Dranesville Elementary working with manipulative devices to discover how things move.

Tier I Priorities: Reforming the Formal Education System

Tier I priorities involve: systemic reform of the elementary and secondary education systems; revitalization of lower-division undergraduate education; and evaluation of Federal education programs at all educational levels. The Federal strategy must undertake all of these activities in parallel to meet expectations for measurable improvements by the end of the decade. In combination, the elements of Tier I define systemic reform. Therefore, while CEHR pursues milestones in parallel, their interdependence is essential.

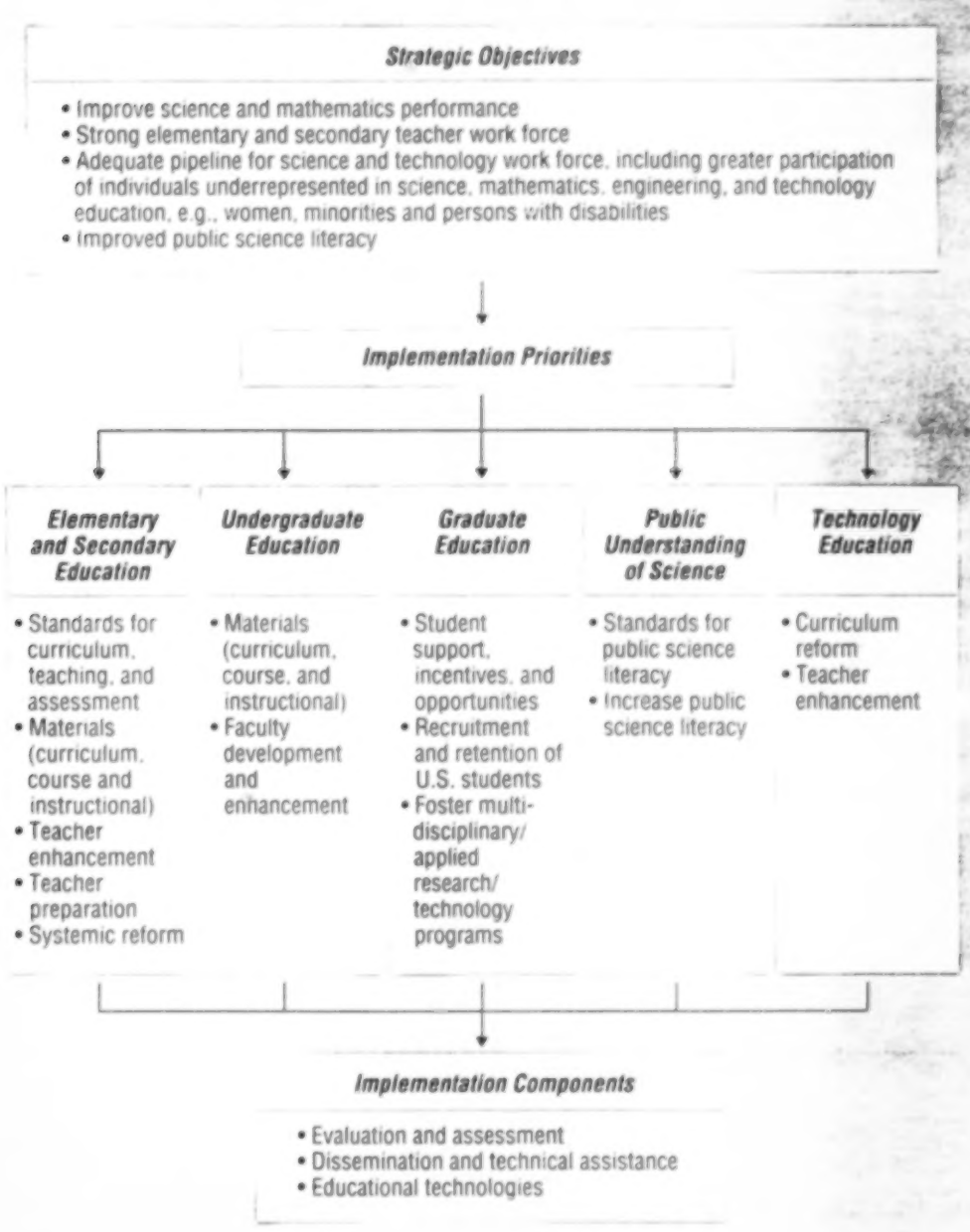
Elementary and Secondary Education: Systemic Reform

Standards for Curriculum, Teaching, and Assessment.
The Federal Government will support:

- Development, through consensus, of world-class curriculum, teaching, and assessment standards that establish the content and skills that both students and educators must master.

- Development of State and district curriculum frameworks for guiding schools in the implementation of these world-class standards.

Federal Science, Mathematics, Engineering, and Technology Education Strategic Planning Framework


Strategic Objectives
• Improve science and mathematics performance
• Strong elementary and secondary teacher work force
• Adequate pipeline for science and technology work force, including greater participation of individuals underrepresented in science, mathematics, engineering, and technology education, e.g., women, minorities and persons with disabilities
• Improved public science literacy
Implementation Priorities
Elementary and Secondary Education
• Standards for curriculum, teaching, and assessment
• Materials (curriculum, course and instructional)
• Teacher enhancement
• Teacher preparation
• Systemic reform
Undergraduate Education
• Materials (curriculum, course, and instructional)
• Faculty development and enhancement
Graduate Education
• Student support, incentives, and opportunities
• Recruitment and retention of U.S. students
• Foster multi-disciplinary/ applied research/ technology programs
Public Understanding of Science
• Standards for public science literacy
• Increase public science literacy
Technology Education
• Curriculum reform
• Teacher enhancement
Implementation Components
• Evaluation and assessment
• Dissemination and technical assistance
• Educational technologies

• Development and adoption of assessment procedures and tools for monitoring student performance and improving instructional strategies and materials.

Successful accomplishment of the foregoing will require active leadership on the part of CEHR agencies.

Milestones:

• In 1994, the National Academy of Sciences (NAS) will complete the development of science curriculum, teaching, and assessment standards with support from the U.S. Department of Education (ED) and the National Science Foundation (NSF), and general consensus building by the NAS with support from NSF, the Department of Energy (DoE), and the National Aeronautics and Space Administration (NASA).

• Beginning in 1994, ED will regularly conduct mathematics and science assessments through the National Assessment of Educational Progress (NAEP) that provide State-by-State comparisons of student performance.

• In 1994 and 1998, ED and NSF will support the development of measures, definition of samples, and administration of international assessments of student performance in mathematics and science.

• By 1995, CEHR agencies will provide support and incentives to encourage all States and school districts to adopt the National Council of Teachers of Mathematics (NCTM) mathematics standards.

• By 1997, CEHR agencies will provide support and incentives to encourage all States and school districts to adopt the NAS-established science standards.

• By 1998, ED will provide support to enable, in all States, the development or revision of mathematics and science curriculum frameworks reflecting world-class standards.

• By 1998, ED and NSF will provide support to enable completion of model assessments for States and others that measure individual student performance against world-class mathematics and science standards.

Materials (Curriculum, Course, and Instructional)

Model curriculum, course, and instructional materials in mathematics and science must be developed for the effective education of *all* students at *all* grade levels. CEHR agencies will ensure the development of materials that address identified needs, communicate scientific principles accurately, and satisfy the existing mathematics and emerging science standards.

Federally supported materials will emphasize active student participation, strengthen problem solving skills, and accommodate student diversity. Special attention will be given to comprehensive instructional materials at the secondary education level, building on those completed for elementary and middle schools.

Milestones:

• Beginning in 1993, CEHR agencies will ensure that all materials developed with Federal support conform to the evolving NAS science standards and to the NCTM standards for mathematics.

• By 1995, NSF will ensure that a comprehensive set of mathematics curriculum models will be available for the elementary through secondary levels.

• By 1997, NSF will ensure that a comprehensive set of science curriculum models will be available for the elementary through secondary levels.

Teacher Enhancement

Immediate upgrading of the existing teacher work force is necessary to improve student performance significantly by the year 2000. A 1988 NSF study, "Course Background Preparation of Science and Mathematics Teachers in the United States," reports that nearly one-half of the Nation's 2.2 million mathematics and science teachers, especially those at the elementary level, require extensive upgrading in *both* disciplinary competency and pedagogical skills.

Such training must meet accepted teaching standards; expose teachers to curriculum standards, high-quality instructional materials, and state-of-the-art disciplinary research and educational technologies; and respond to cultural diversity. All CEHR agencies will contribute to the achievement of this goal.

◀ *A Teacher Workshop at NASA's Teacher Resource Center at John C. Stennis Space Center, Miss.*

FY 1994 Federal Science, Mathematics, Engineering, and Technology Education Priority Framework

Base Program

- Maintain and capitalize on current world-class programs (e.g., graduate education, student incentives and opportunities, education technology ...) and opportunities for groups underrepresented in mathematics and science (e.g., women, minorities, and persons with disabilities)

Tier I Priorities: Reforming the Formal Education System

Elementary and Secondary: Systemic Reform

- Curriculum, teaching, and assessment standards: development and implementation
- State curriculum frameworks: development and implementation
- Curriculum, course, and instructional materials: development and implementation
- Teacher enhancement and preparation

Undergraduate: Revitalization

- Curriculum, course, and instructional materials: development and implementation (lower-division)
- Undergraduate faculty enhancement

All Education Levels: Evaluation

- Evaluation of Federal agency programs

Tier II Priorities: Expanding Participation and Access

- Increase participation of groups underrepresented in science, mathematics, engineering, and technology: all education levels
- Identify, disseminate, and promote adoption of exemplary program strategies and materials: all education levels
- Identify Federal strategies to employ educational technologies more broadly

Tier III Priorities: Enabling Activities

- Increase public understanding of science
- Promote formation and strengthening of partnerships between two-year institutions and other sectors

Milestone:

• From 1993 through 1998, 600,000 teachers — emphasizing those at the elementary level — will receive intensive disciplinary and pedagogical training through Federal agency teacher enhancement programs.

— In 1993, 45,000 teachers will participate in such training through ED, NSF, and mission agency programs.

— From 1994 through 1995, the number of teachers in such programs will increase by 50 percent per year.

— From 1996 through 1998, the number of teachers in such programs will increase by 10 percent per year.

Teacher Preparation

According to the Chief State School Officers' report "State Indicators of Science and Mathematics Education 1990," based on ED's 1988 School and Staffing Survey, only 42 percent of public high school mathematics teachers and only 54 percent of public high school science teachers have college majors in their teaching discipline. The situation is even more severe with elementary education teachers of the general curriculum, most of whom have taken very few mathematics and science courses in college. For example, only 34 percent of science teachers in grades K-6 met the National Science Teachers Association standards of course work in all three science areas, based on the NSF-supported study previously cited.

Teacher preparation programs must conform to the new standards. CEHR proposes that States be encouraged — with a variety of incentives — to revise their teacher certification requirements to ensure that *all* teacher graduates are fully prepared to teach world-class mathematics and science. Additionally, long-term strategies must overcome barriers between schools of education and other academic departments, such as science and engineering. These strategies must also link preservice instruction to classroom practice.

Milestones:

• In 1993 and 1994, CEHR agencies will sponsor the development of model teacher preparation consortia that link schools of education and other academic departments, launching a new, more effective, intellectually and pedagogically appropriate mode of preservice teacher education.

• By 1996, eight geographically distributed teacher preparation consortia will be in place.

• By 1998, the Federal Government will provide support and incentives to encourage all new elementary teachers to be educated in teacher preparation programs that reflect world-class standards in mathematics and science. These programs should be driven by new teacher certification requirements that conform to world-class standards.

• By 2000, one-third of all new secondary science and mathematics teachers will graduate from schools participating in the consortia-sponsored programs.

Undergraduate Education: Revitalization

Materials (Curriculum, Course, and Instructional)

Lower-division (freshman and sophomore) curricula must be continually updated given the ever-expanding wealth of knowledge being generated and the emergence of new fields in science, mathematics, engineering, and technology resulting from this knowledge. In addition, mathematics and science education at the secondary levels must reflect this evolutionary knowledge base. Therefore, lower-division college and university courses in science, mathematics, engineering, and technology must be revitalized to:

• Provide strong disciplinary and cross-disciplinary training of future mathematics and science teachers.

• Attract and retain students to major in these fields and provide them with a solid grounding in the core subjects.

• Strengthen technology education (especially in two-year institutions).

• Advance the scientific literacy of all students.

A senior student at Thomas Jefferson High School for Science and Technology working in the laser lab.

CEHR agencies will promote disciplinary and cross-disciplinary reform through the development of curriculum models and exemplary materials and will provide other incentives to help achieve these changes.

Milestones:

• By 1995, CEHR agencies will contribute to revitalized science, mathematics, engineering, and technology education at colleges and universities benefiting at least one-third of the students enrolled in lower-division studies.

• By 1998, CEHR agencies will contribute to revitalized science, mathematics, engineering, and technology education at colleges and universities benefiting at least two-thirds of the students enrolled in lower-division studies.

Faculty Development and Enhancement

Teaching faculty, especially faculty concerned with freshmen and sophomores, are central to the success of undergraduate education in science, mathematics, engineering, and technology. They must be proficient in state-of-the-art technology and instrumentation, new experimental methods, and emerging pedagogical techniques.

Milestones:

• By 1996, CEHR agencies, in cooperation with industrial organizations, will expand programs and activities to provide research-related experiences at university, Federal, and industrial laboratories for at least 16,000 undergraduate faculty involved in teaching science, mathematics, engineering, and technology.

• By 2000, CEHR agencies and industrial partners will expand programs and activities to provide research-related experiences for at least 50,000 of the undergraduate teaching faculty of science, mathematics, engineering, and technology.

Evaluation of all Federal Agency Programs

Evaluation of CEHR Programs

All CEHR programs address identified needs, make efficient use of available resources, and contribute to improving results in science, mathematics, engineering, and technology education. Evaluation is the basis for measuring results, ensuring accountability, and strengthening programs. Several CEHR agencies, including ED, NSF, DoE, and NASA, have evaluated their programs or a subset of their programs for many years. Expertise developed through these evaluations will be shared with all CEHR agencies as the new coordinated evaluation strategy is implemented. Each agency must conduct more uniform program reviews and evaluations to help CEHR determine results in these areas.

Under NSF leadership, CEHR will devise a coordinated strategy for the ongoing evaluation of member agencies' programs. Each agency is strongly encouraged to participate in this process and build the requisite knowledge and budgets to support this activity.

Milestones:

• In 1992, under NSF leadership, CEHR will establish an Evaluation Working Group with representatives from all member agencies. This standing working group will coordinate evaluation plans across CEHR agencies, develop procedures, and recommend outcome indicators.

• In 1992, NSF will create an external expert panel to inform CEHR agencies of evaluation needs.

• In early 1993, the expert panel will report to CEHR on the assessment of the merits of member agency programs and the Federal strategy.

• In 1993, the Evaluation Working Group will assist in the design of an assessment study on the capacity, roles, and accessibility of Federal laboratories for teacher enhancement; the assessment study will be completed and the results reported to CEHR in 1994.

• In 1993, each CEHR agency will develop plans for evaluating its science, mathematics, engineering, and technology education programs. The plan will include those programs for which an evaluation is to be completed by 1998 and will indicate the year(s) in which each evaluation will be conducted.

• In 1995, each CEHR agency will complete the evaluation of its highest priority programs and its plans for dissemination of the results to CEHR agencies.

• By 1998, each agency will complete its first cycle of program evaluations and will disseminate the results.

Tier II Priorities: Expanding Participation and Access

Restructure Programs to Increase Participation of Underrepresented Groups in Science, Mathematics, Engineering, and Technology

To ensure the availability of a highly trained scientific and technical work force, the Nation must strive to promote the increased participation of individuals underrepresented in science, mathematics, engineering, and technology education. In particular, women, minorities, and persons with disabilities must be more fully represented in these education programs and ultimately in our work force.

Despite sustained Federal investment and the emergence of programs to promote the participation of underrepresented individuals over the past several decades, we have achieved insufficient progress. While CEHR member agencies have a clear understanding of the underlying issues and possess examples of successful programs, a comprehensive, integrated Federal management strategy is needed to disseminate innovative and successful approaches to increase access, participation, and representation across the entire education continuum.

The single most important way to expand participation and access of underrepresented groups is to open the education pipeline that begins in kindergarten and continues through elementary and secondary school. It is highly desirable that States and localities increase the participation of women, minorities, and persons with disabilities in the study of the gatekeeping subjects of algebra, geometry, chemistry, and physics, as well as among those majoring in mathematics and science in college. In addition, with the aggressive pursuit of Tier I priorities that provide every student with the opportunity and encouragement to study mathematics and science from kindergarten through high school, the supply of well-educated students from underrepresented groups will expand.

Milestones:

• In 1993, CEHR will define a set of objectives that challenge Federal programs to increase participation of groups underrepresented in the scientific and technical work force.

• In 1993, CEHR will develop realistic and widely applicable measures to identify successful programs and exemplary products that contribute to increasing the participation of groups underrepresented in science, mathematics, engineering, and technology.

Advanced placement students in Thomas Jefferson's Chemical Analysis Lab producing a chemical reaction.

• In 1994, CEHR will examine its programs against these measures, identifying those suitable for replication, and develop a coordinated strategy that covers the entire education continuum and capitalizes on the strengths of participating agencies.

• In 1995-1996, CEHR will implement the coordinated strategy.

Dissemination of High-Quality Material at All Education Levels

CEHR will take steps to identify exemplary programs and instructional materials for dissemination to administrators, faculty, teachers, and students. CEHR strongly endorses a coordinated dissemination effort that integrates existing systems and eliminates the duplication of effort.

Effective dissemination, however, does not ensure use. Outreach and technical assistance activities that promote adoption and implementation in the field must also be developed. CEHR agencies must capitalize on the potential for the integration of activities, such as teacher training and instructional materials development programs.

Milestones:

• In 1993, CEHR, through its Dissemination Working Group, will develop a set of standards reflecting world-class mathematics and science standards and each agency will put mechanisms in place that evaluate the quality of the instructional materials developed under its support.

• By 1995, each CEHR agency will begin to evaluate its products to ensure that quality standards are met.

• From 1993 through 1998, agencies will actively disseminate, on a continuing basis, high-quality products through such means as Federal clearinghouses, electronic networks, and commercial vendors.

Identify Federal Strategies to Increase Use of Educational Technologies

Emerging technologies show great promise for enhancing student learning and participation in scientific research. CEHR views the Federal role in educational technology as supporting research and development, implementation, and infrastructure development.

CEHR agencies will: identify technology-related activities (both Federal and non-Federal) that demonstrate the greatest potential for improving the delivery of science, mathematics, engineering, and technology education; develop resident expertise to understand better the role that technologies can play in their education-related activities; and share information through a standing Educational Technologies Working Group.

Milestones:

• In 1993, CEHR agencies will inventory their educational technology-based activities (e.g., computational mathematics and science tools, learning environments, teaching aids and tutoring systems, and electronic networking and distance learning).

• By 1994, CEHR agencies will ensure that at least 20 percent of the Nation's secondary schools participate in at least one technology-based research project involving working relationships with the scientific community.

• By 1994, CEHR agencies will develop and communicate a national vision for networked resources through a plan reflecting input from local, State, and Federal agencies and involving public and private stakeholders.

• In 1995, CEHR agencies will sponsor educational technology activities that reflect the national vision and demonstrate significant potential for increasing student performance.

Tier III Priorities: Enabling Activities

Public Understanding of Science

To ensure our global competitiveness, the United States must have scientifically literate citizens capable of understanding complex economic, political, ethical, and social issues derived from an increasingly technological society. Moreover, a scientifically literate public will understand the need for a robust research enterprise and will encourage and motivate our youth to study mathematics and science. Without this encouragement, the science education efforts of the Federal Government will be less effective.

Milestones:

• In 1994, CEHR, under the leadership of the Department of Health and Human Services (HHS), will convene a consensus development conference to assess alternative sets of standards for public understanding of science, including public science literacy; identify data needs; and propose effective education strategies, with a special emphasis on reaching underserved populations.

• In 1995, CEHR will identify and adopt science literacy standards, based on the recommendations of the consensus development conference.

• Beginning in 1996, CEHR agencies will revise and strengthen their programs to increase public understanding of science in order to satisfy the science literacy standards.

• By 1998, CEHR agencies will take steps to increase the proportion of scientifically literate U.S. adults by 50 percent.

Promote Formation and Strengthening of Partnerships Between Two-Year Institutions and Other Sectors

Two-year colleges are an important segment of the education pipeline for scientists, engineers, and elementary and secondary mathematics and science educators. Moreover, these institutions play an important role in training technicians and increasing the scientific literacy of their students, regardless of academic major.

Parts of the telescope are explained by the teacher to students.

CEHR agencies should be responsive to the needs of these institutions and strengthen their role in the education continuum. Federal programs should stimulate stronger linkages between two-year colleges and the elementary, secondary, and upper-division undergraduate sectors. Such programs will facilitate student enrollment, program articulation, and improved instruction.

Milestone:

• By 1994, CEHR agencies will expand activities that promote linkages between two- and four-year institutions and between two-year colleges and high schools.

Future Directions

CEHR is an important mechanism for integrating and strengthening Federal science, mathematics, engineering, and technology education activities. Attaining the goals of the Strategic Plan will require not only a continuation or enhancement of current activities, but also the implementation of new efforts tied to specific priorities and milestones identified in the Plan.

Some of these efforts will require new programs in CEHR agencies. Others can be undertaken through a refocusing of current activities, while still others can be implemented through Presidential directives. For example, inner cities present a challenge for education in general and certainly to mathematics and science education. In particular, data indicate that inner-city students have the lowest achievement score of any population group. They are also less likely to be taught by certified mathematics and science teachers than are their suburban counterparts.

But cities also have unique programs and institutions that could provide strong support for reform and innovation in mathematics and science. Some CEHR agencies have substantial investments in urban areas. CEHR intends to provide a structure for its urban efforts consistent with appropriate elements of its Strategic Plan. In addition, CEHR will identify exemplary programs and work closely with key organizations, inside and outside of government, in order to maximize resources for inner-city students.

In addition, recognizing an increasingly diverse student population and labor force and a changing workplace, CEHR acknowledges the importance of education, training, and retraining programs that are designed to enhance the capability of different segments of the current work force and of new work force entrants. This is a complex issue that warrants specific attention by the CEHR Technology Education Working Group.

◀ *A senior student looking at lift and drag measurements of the air flow in a wind tunnel.*

Milestones:

• In 1993, CEHR agencies will convene a panel/roundtable of experts to explore and identify the Federal role in technology education.

• During 1993, the Technology Education Working Group will develop a technology education inventory to determine the scope of current Federal programs.

• In 1994, CEHR will convene a conference of training managers from industry, labor, government, and professional associations to develop an

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approach for understanding and clarifying the customer requirements for technology education.

In future years, CEHR agencies — working on their own or in tandem — may propose additional initiatives to hasten national progress toward attaining the Strategic Plan milestones. These initiatives will be most effective if considered through the CEHR strategic planning and budget development processes, through which missions and activities can be assigned to the most appropriate agencies and unnecessary duplication avoided. Each CEHR agency will further propose incentives and consequences for participants receiving agency resources. Accordingly, CEHR will continue its discussions on future directions during 1993.

◂ *Fifth graders at Dranesville Elementary's Music Room learn how to compose on the "MIDI" hooked into a Macintosh computer.*

Management Plan

CEHR and Agency Roles

CEHR has developed this Plan for the management and coordination of the Federal Government's efforts in science, mathematics, engineering, and technology education. The merit of the Plan notwithstanding, the outstanding challenge is its implementation. Implementation of this Plan will occur through the management process described below. This framework continues the planning and coordination efforts CEHR has undertaken over the past three years. Agency activities implementing this Plan are referred to as the U.S. Science, Mathematics, Engineering, and Technology Education Program (US/SMETE Program).

Second grade students holding a model of the Space Shuttle.

CEHR is charged with guiding the overall US/SMETE program. Each individual agency, however, is responsible for operating and managing its assigned programs. In accordance with its charter, CEHR will support and facilitate program implementation and operation by ensuring:

- Communication among agencies.
- Coordination of programs.
- Leadership in development of new initiatives.
- Establishment of program linkages.
- Establishment of multiagency Memoranda of Understanding (MOUs).
- Strategic planning and budget development.

Interagency Coordination

An overall CEHR US/SMETE Program Subcommittee will be established. Under the Subcommittee, supporting working groups, one for each of the activity clusters shown in the Priority Framework, will provide continuing support of the Federal Government's science, mathematics, engineering, and technology education efforts. These groups will monitor progress toward achieving the milestones and ensure interagency coordination and communication.

CEHR agencies will continue aggressively to seek opportunities for collaboration and cooperation in achieving the goals and milestones established in the Strategic Plan. A number of formal MOUs have been developed between CEHR agencies to establish joint efforts in science, mathematics, engineering, and technology education. For example, NSF and ED have developed formal mechanisms for cooperation in precollege education, while DoE and the

Environmental Protection Agency (EPA) have agreed to collaborate in the areas of energy and environmental education.

US/SMETE Program Subcommittee Working Groups

The role and scope of activity for each working group under the US/SMETE Program Subcommittee is derived from the CEHR Charter. NSF and ED will co-chair the Subcommittee, and the following list indicates which agency will assume leadership responsibility for each working group.

Working Groups

- Elementary and Secondary Education Systemic Reform: NSF and ED, Co-Chairs.
- Undergraduate Education Revitalization: NSF, Chair.
- Evaluation of Federal Agency Programs: NSF, Chair.
- Increased Participation of Groups Underrepresented in Science, Mathematics, Engineering, and Technology: ED, Chair.
- Identification, Dissemination, and Adoption of Exemplary Program Strategies and Materials: ED, Chair.
- Educational Technologies: NASA, Chair.
- Public Understanding of Science: HHS/NIH, Chair.
- Graduate Education: USDA, Chair.
- Technology Education: DoE, Chair.

The responsibility of the Elementary and Secondary Education Systemic Reform Working Group will be divided according to the roles identified in the Strategic Plan, i.e., teaching and assessment standards development (ED), and curriculum and teacher enhancement development (NSF).

Membership on these working groups will be composed of agencies that have activities essential to meeting the milestones in the Strategic Plan. The overall US/SMETE Program Subcommittee will establish procedures to permit any agency to raise relevant issues for consideration by the appropriate working group.

CODA

The United States is regarded as the world leader in advanced studies. In fact, the central role of the United States in promoting basic scientific knowledge and research is almost a cliche. Nevertheless, while CEHR recognizes the importance of maintaining our world-class university system, CEHR also recognizes the education challenge facing us in improving mathematics and science at the elementary and secondary school levels and in creating a more scientifically literate citizenry.

For too long, our Nation has deferred the necessary improvement in its elementary and secondary education system. It did not, until recently, elect to formulate and implement mathematics and science standards, and it has not set student performance expectations, implemented developmentally and pedagogically appropriate mathematics and science curricula, and ensured challenging, appropriate, and quality preparation of the mathematics and science instructional work force. The results of past omissions are evident: a general faltering of education expectations and performance indices; a citizenry educated less broadly and less intensively than is demanded by the workplace; and poor connectivity between the educational and economic systems. Accordingly, for a decentralized elementary and secondary system of 46.8 million students, 2.2 million teachers, and over 100,000 schools, nothing less than a comprehensive, systemic, and fundamental reform of the mathematics and science education enterprise is indicated.

This Strategic Plan acknowledges the urgency and innovation required to reach our national goal of being first in the world in mathematics and science education. The Plan builds on and encourages the education reform efforts underway and promotes a permanent change in the Nation's educational efforts.

The fundamental core of this change must be the adoption, without exception, of a vigorously held notion that *all* American children must have equal opportunity to participate in rich, intellectually challenging mathematics and science curricula taught by well-qualified elementary and secondary teachers. In implementing this Plan, each component of the elementary and secondary education system — from mathematics and science standards to teacher enhancement and preparation, from revised teacher certification procedures to improved curriculum and materials — must be affected.

The CEHR agencies have a compelling responsibility to provide national leadership that sets the foundation for *reformed* elementary and secondary mathematics and science education in the United States. The Plan sets priorities for individual agendas and collaborative Federal agency action in pursuit of this national goal. It seeks to make optimum use of Federal education

resources by combining existing programs with new initiatives and to more effectively tap the vast scientific and technical resources of the Federal Government. Such a comprehensive strategy will help our country excel in the future.

Mathematics and science education is now inseparably coupled to the skills of the scientific and technical work force, to the development of critical technologies, and thereby to the state of the national economy in a competitive, global arena. We also need mathematics and science skills and knowledge to address the many other issues facing our Nation — including protecting the environment, discovering cures for life-threatening diseases, and rebuilding our cities and infrastructure.

Thirty years ago we made a commitment to put a man on the moon within a decade. We now need a similar commitment to revitalize and reinvigorate our education system. This time, it is not a matter of national pride, but rather a matter of economic and social necessity.

Appendix

Title 3—
Executive Order 12821 of November 16, 1992

The President

Improving Mathematics and Science Education in Support of the National Education Goals

By the authority vested in me as President by the Constitution and the laws of the United States of America, including the provisions of the Stevenson-Wydler Technology Innovation Act of 1980, as amended (15 U.S.C. 3701, *et. seq.*), and the Federal Property and Administrative Services Act of 1949, ch. 288, 63 Stat. 377 (codified as amended in scattered sections of the United States Code), and in order to endure that Federal departments agencies and laboratories assist in mathematics and science education to meet the National Education Goals, it is hereby ordered as follows:

Section 1. *Assistance in Mathematics and Science Education.* (a) Each executive department and agency (hereinafter referred to as "agency") that: (i) has a scientific mission; (ii) employs significant numbers of scientists, mathematicians, and engineers; or (iii) has a Federal laboratory; as determined by the Committee established by section 2 (d) of this order, shall, to the maximum extent permitted by law:

(1) Assist in the mathematics and science education of our Nation's students, teachers, parents, and the public by establishing programs at their agency to provide for training elementary and secondary school teachers to improve their knowledge of mathematics and science. Such programs, to the maximum extent possible, shall involve partnerships with universities, State and local elementary and secondary school authorities, corporations, and community based organizations. These activities shall be coordinated with other relevant Federal teacher training programs (e.g., those administered by the National Science Foundation, the Department of Education, and the Department of Energy). Because of its extensive experience in teacher training programs at its Federal laboratories, the Department of Energy, when requested by other agencies, shall assist in the development of these activities.

(2) Provide brief periods of excused absence for Federal employees to assist in the conduct of mathematics and science education programs, in accordance with guidelines of the Office of Personnel Management.

(b) Develop, within 6 months of the issuance of this order, an implementation plan to fulfill the requirements of this section. The plan shall be consistent with approved agency budget totals. The plan shall be coordinated through the Committee on Education and Human Resources of the Federal Coordinating Council for Science, Engineering, and Technology.

Sec. 2. *Transfer of Education-Related Federal Equipment to Elementary and Secondary Schools.* (a) To the maximum extent permitted by law, all agencies shall give highest preference to elementary and secondary schools in the transfer or donation of education-related Federal equipment. All such transfers to the schools shall be made at the lowest cost permitted by law.

(b) Each agency, to the maximum extent permitted by law, shall:

(1) Identify and transfer excess education-related Federal equipment at that agency that can be transferred to elementary and secondary schools by:

(A) Direct transfer of excess Federal research equipment in accordance with the provisions of subsection 3710(i) of the Stevenson-Wydler Technology Innovation Act of 1980, as amended (15 U.S.C. 3710(i)). The transfer of such excess equipment shall be reported to the General Services Administration (GSA); or

(B) Reporting such excess equipment to the GSA for donation when declared surplus in accordance with the provisions of section 203(j) of the Federal Property and Administrative Services Act of 1949, as amended (40 U.S.C. 484(j));

(2) Allow the elementary and secondary schools sufficient time to select available education-related Federal equipment before it is disposed of elsewhere;

(3) Provide training and technical assistance, where possible, to recipients of education-related Federal equipment to ensure that the equipment will be utilized to its full capability; and

(4) Attempt to provide education-related Federal equipment to those elementary and secondary schools with the greatest need or to the recipients of federally funded mathematics and science projects where the equipment would further enhance the progress of the project.

(c) The GSA shall:

(1) To the maximum extent permitted by law, ensure that elementary and secondary schools are notified of the opportunity to obtain education-related Federal equipment, and, where practical, provide to elementary and secondary schools a current listing of education-related Federal equipment that is available for transfer, and, when requested, provided a current listing of this available equipment to agencies; and

(2) Maintain a record of the education-related Federal equipment provided to elementary and secondary schools pursuant to this order.

(d) There is hereby established a Coordinating Committee on Education-Related Federal Equipment (Committee). The Committee membership shall include, but not be limited to, representatives of the Departments of Defense, Education, Energy, and Health and Human Services, the National Science Foundation, the General Services Administration, and the National Aeronautics and Space Administration.

(1) The Co-chairs of the Committee shall be the Administrator of General Services and the Secretary of Education, or their designees.

(2) The Committee shall assess the availability of appropriate education-related Federal equipment and mechanisms for expeditious notification and transfer of the equipment to elementary and secondary schools and shall resolve issues that may arise in implementing this order.

(3) The Committee shall inform, as necessary, non-Federal groups (e.g., National Governors Association, State Agencies for Surplus Property, etc.) of issues concerning the transfer of education-related Federal equipment.

(4) The Committee may consult with the Committee on Education and Human Resources of the Federal Coordinating Council for Science, Engineering, and Technology concerning activities outlined in this order, particularly those activities listed in section 1 of this order.

Sec. 3. *Definitions.* For the purposes of this order:

(a) "Education-related Federal equipment" means excess or surplus personal computers and related peripheral equipment, research equipment, and education-related equipment that is appropriate for use in mathematics and science curricula in elementary and secondary school education.

(b) "Elementary and secondary schools" means individual public or private educational institutions encompassing kindergarten through twelfth grade, as well as public school districts.

(c) "Federal laboratories" has the meaning set forth in the Stevenson-Wydler Technology Innovation Act of 1980 (15 U.S.C. 3710a(d)(2)).

(d) "Research equipment" means excess or surplus Federal property appropriate for mathematics and science education activities at the elementary and secondary education levels, as defined by and in accordance with the regulations of the agency that owns the research equipment.

George Bush

THE WHITE HOUSE
November 16, 1992

Federal Coordinating Council
for Science, Engineering,
and Technology

Committee on Education
and Human Resources

U.S. Science, Mathematics, Engineering, and Technology Education Strategic Plan FY 1994 - FY 1998

EP-288